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Noise Barrier Attenuation

Highway 417, North Side

East of Island Park Drive, Ottawa

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ABSTRACT AND EXECUTIVE SUMMARY

This report describes the acoustical performance of a 4 m high noise barrier built in 1980 on the north side of Highway 417 between Melrose Avenue and Island Park Drive in Ottawa.

At the site's western half, in the back yards of homes closest to the highway, the average barrier sound reduction was 8 dBA. At the eastern half, the corresponding reduction was 2 dBA. At more distant locations, the average sound level reductions ranged from 1 to 4 dBA.

The measured noise barrier attenuations were broadly in agreement with calculated attenuations using both BBN and FHWA highway noise computer programs. Since the site was already protected from noise by the shoulder of the road, attenuations were not expected to be high.

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1/ INTRODUCTION

This is the 6th report presenting results of acoustical evaluation of highway noise barriers built by the Ministry of Transportation and Communications. The previous reports in this series are listed as References 1 to 5.

The barrier evaluated in this report was erected in 1980 on the north side of Highway 417, between Melrose Avenue and Island Park Drive, Ottawa. The barrier is approximately 1300 m long and its top is about 4 m above pavement elevation. At the location of the barrier, Highway 417 consists of six traffic lanes and is elevated above the surrounding flat terrain. The height of the highway elevation ranges from 1.5 to 6 m. Barrier photographs are shown in Figures 1 and 2, while Figure 3 provides an overview of the site.

The acoustical performance of the barrier was assessed by comparing sound levels taken before barrier construction with those taken after barrier construction. The before and after sound levels were measured at 35 points behind the barrier as shown in Figure 3.

The instrumentation, measurement and evaluation methods used were similar to those used previously and described in References 4 and 5. Briefly, two or more digital sound level monitors were used simultaneously (one monitor being at a "control" location, and any others at receiver locations) to account for traffic variation between before and after conditions. Measurement locations were generally 1.2 m above ground.

It should be pointed out that the acoustical evaluation of the barrier was done without the presence of the planned, opposing south-side barrier. The future erection of a barrier on the opposite site may slightly degrade the acoustical performance of the present barrier.

2/ MEASURED SOUND LEVELS

2.1/ Measurements Before Barrier Construction

The majority of before-barrier measurements were conducted in December, 1978, and in January, 1979, when the ground was covered with snow and there was also a low snow bank alongside the highway shoulder. This snow bank is shown on the photograph of Figure 2. The results of these measurements were reported in Reference 6.

In addition to this, supplementary before-barrier measurements were taken at the west end of the site in November, 1979, when snow was absent.

Sound level measurements before and after barrier construction, as well as sketches of the additional measurement locations are presented in Appendix A as Table A1 and Figures A1 to A3, respectively.

2.2/ Measurements After Barrier Construction

The after-construction sound level measurements were taken at the same locations as their before-barrier counterparts in July and November, 1980. The exact dates and times of all measurements are given in Table A1 in Appendix A.

2.3/ Measured Sound Level Reductions

The measured barrier insertion loss is given in Table A1 in terms of L_{eq} and L_{50} levels for all 35 measurement locations. For clarity, the measurement points have been segregated into four groups (and four tables) according to the degree of their shielding provided by the houses present:

- measurement locations unshielded by houses - Table 1a,
- measurement locations partially shielded by one row of houses - Table 1b,
- measurement locations shielded by one row of houses - Table 1c
- measurement locations shielded by two or more rows of houses - Table 1d.

The measured insertion loss in Tables 1a to 1d is an average insertion loss obtained by several measurements. Also given are calculated sound levels discussed in Section 3.

2.3.1/ Locations Unshielded by Houses

Eleven measurement locations unshielded by houses were evaluated. The results are given in Table 1a. Measured barrier insertion loss (measured attenuation) at the first row of houses averaged only 2.5 dBA.

Particularly small barrier insertion loss was measured behind the eastern half of the barrier near Parkdale Avenue (measurement locations 6, 9, 11, 13, 16 and 19) where practically no insertion loss was achieved. The main reason is that this section was already protected from highway noise by the elevated shoulder of the highway before the barrier was built. Furthermore, ambient noise in this area is strongly influenced by local traffic and traffic on ramps which was not shielded by the barrier. The measured barrier insertion loss at the western half (measurement locations 25, 27, 29, 30, 34) averaged 6 dBA at the first row of houses.

The above measured barrier insertion loss is based on before-construction measurements conducted during winter of 78/79 when snow formed a low bank alongside the highway shoulder. Due to the source-receiver geometry, the snow bank acted as an effective noise barrier reducing the before-construction sound levels. Consequently, measured insertion loss of the barrier was also reduced. The average amount of this reduction was calculated to be about 2 dBA. Thus, the actual insertion loss achieved at the site's eastern half was about 2 dBA; at the western half about 8 dBA. The average insertion loss for all unshielded, first-housing row receivers was about 4.5 dBA.

2.3.2/ Locations Partially Shielded by One Row of Houses

Results for 5 measurement locations partially shielded by one row of houses are given in Table 1b. The average measured barrier insertion loss was about 3 dBA. Discounting the influence of the snow bank discussed previously, the average effective insertion loss was calculated to be about 1 dBA higher i.e. 4 dBA.

2.3.3/ Locations Shielded by One or More Rows of Houses

Results for 16 measurement locations shielded by one or more rows of houses are summarized in Tables 1c and 1d. Considering the influence of the snow bank during the before measurements, the effective barrier insertion loss at these locations was about 0 to 1 dBA. The directly measured insertion losses reported in Tables 1c and 1d actually indicate a small (1 dBA) increase in sound levels (amplification). This does not necessarily mean an actual long-term increase in the after-construction sound levels. Several considerations in addition to the effect of the snow bank must be taken into account when interpreting the directly measured amplifications.

a) Short-Term Sound Level Variations

Sound levels at locations shielded by houses are not solely governed by noise emitted by the freeway but are also influenced, to a considerable degree, by highly variable community noise sources and by environmental (weather-related) factors. A quantitative evaluation of these factors was presented in Reference 5.

b) Effect of Snow Cover

The before measurements were conducted during winter when the ground was covered with snow. The after measurements were conducted without snow cover. The sound absorption effect of the snow covered ground, in addition to the effect of the snow bank, may have reduced the before-construction sound levels. This would result in a lower measured insertion loss.

c) Typical Community Sound Levels

Expressway traffic is only one of the many community noise sources. Indeed, without the presence of an expressway, or any other major traffic artery, typical ambient L_{eq} sound levels in a residential area during daytime can be expected to be in the 50-55 dBA range. For example, the sound levels in single-family residential areas in London and Woodstock, Ontario, reported in Reference 7, averaged about 55 dBA. This compares quite favourably with the measured after-construction sound level presented in Tables 1c and 1d, which averaged about 54 or 55 dBA. (The measured before-construction sound levels were even slightly lower).

It is probably unrealistic to expect a signifiant reduction in sound levels if the residential levels are already in the 50 to 55 dBA range, even if the contribution of the freeway traffic noise was completely eliminated.

The relationship between the before-construction sound levels and the measured insertion loss (in Figure 4) shows that barrier insertion loss is generally greater at locations where before-barrier-construction sound is loudest. Figure 4 also suggests a difficulty in achieving the barrier insertion loss when the before-construction sound levels are lower than about 58 or 60 dBA.

3/ COMPARISON OF MEASURED AND PREDICTED BARRIER INSERTION LOSS

The predicted barrier insertion loss was calculated using two highway noise prediction programs:

- Standard BBN computer program (8), and
- STAMINA developed by U.S. Federal Highway Administration (9).

3.1/ BBN Computer Program

The before and after construction sound levels were calculated using the highway noise computer program (described in Reference 7) which is also used to prepare acoustical design advice for noise barriers. The difference between the before and after construction sound levels represents the calculated barrier attenuation. MTC has adjusted the output of this program to introduce a reduction of 2 dBA in barrier attenutaion to modify it according to previous experience.

3.2/ STAMINA Computer Program

The STAMINA computer program is a computerized version of the U.S. Federal Highway Administration highway traffic noise prediction model (10). The output of this program was also modified to introduce a reduction of 2 dBA in barrier attenuation. Since the shielding effect of houses cannot be modelled by STAMINA, only unshielded locations were evaluated by this program.

Traffic volumes used for barrier attenuation calculations approximated traffic volumes experienced during field sound measurements.

The results presented in Table 1a indicate that both programs, as well as field measurements, yielded roughly similar values. For example, the average insertion loss predicted by the BBN program was 3.8 dBA, the corresponding value predicted by STAMINA was 3.7 dBA and the measured value was 2.5 dBA.

Tables 1b to 1d present a similar comparison of measured and predicted levels for locations partially shielded and fully shielded by houses. In general, the predicted barrier insertion loss was overestimated; probably for the reasons discussed in Section 2.3.3.

4/ CONCLUSIONS

1. The average measured barrier insertion loss in adjacent-to-barrier yards behind the western half of the barrier was about 8 dBA. The corresponding insertion loss behind the eastern half was about 2 dBA.
2. The average measured barrier insertion loss at more distant locations, partially or fully shielded by houses, ranged from 1 to 3 dBA.
3. The average measured sound attenuations provided by the barrier were broadly in agreement with calculated attenuations. Since the site was already protected from noise by the shoulder of the road, attenuations for ground receivers were not expected to be high.
4. Both computerized highway noise prediction methods used for estimation of the barrier insertion loss (BBN method and STAMINA) produced similar results.
5. Before-construction sound levels measured at locations shielded by one or more rows of houses were in the range of 46 to 56 dBA (L_{eq}). Since this is also a range of typical ambient sound levels encountered in residential areas not subjected to freeway noise, it is unlikely that such sound levels can be significantly reduced even by entirely eliminating the freeway noise. Consequently, only nominal barrier attenuation was obtained for these locations.

5/ ACKNOWLEDGEMENTS

The sound level measurements reported in this report are the work of Experimental Demonstration and Testing Laboratory staff, particularly Messrs. J. Desormeaux, G. Giles and J. Egan. The noise predictions by BBN program were done by Mr. M. R. Hunter, Consultant. Tables in the Appendix were prepared by Mr. C. Blaney of Experimental Demonstration and Testing Laboratory.

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Table 1a/ COMPARISON OF MEASURED AND PREDICTED SOUND LEVELS
(Locations Unshielded by Houses)

Measurement Location	After-Construction Sound Levels, L_{eq}			Barrier Insertion Loss, L_{eq}			
	Measured	Calculated		Measured	Calculated		
		BBN	FHWA		BBN	FHWA	Correction
1	2	3	4	5	6	7	8
Locations 1.2 m above ground							
6	62.7	62.0	63.2	0.3	1.0	0.5	S
9	61.4	65.0	64.4	-0.2*	0.5	0.9	S
11	59.4	63.0	63.3	-0.3*	0.5	0	S
13	59.4	63.0	64.0	-2.4*	0.5	0	S
16	57.9	61.0	61.9	1.6	2.5	2.2	S
19	56.6	61.0	59.4	-1.6*	1.5	2.8	S
25	67.9	63.0	65.0	8.6	10.5	10.5	S
27	63.9	62.0	63.0	4.1	7.0	6.1	S
29	62.1	61.0	62.8	2.8	6.0	5.3	S
30	62.1	60.0	63.6	7.4	N/A	5.5	-
34	66.5	63.5	64.5	7.0	8.0	6.9	-
Average:	61.8	62.2	63.3	2.5	3.8	3.7	
Locations at different heights above ground, m							
30:3 m	62.6	63.0	-	9.2	9.0	-	-
30:5 m	66.5	66.0	-	4.3	6.0	-	-

Notes:

1) Measurement locations are shown in Figure 3 and are documented in Reference 6 and in Appendix A
2) Average measured value if appropriate. Unadjusted for traffic and other variations
3) Adjusted for traffic and other variations using control measurements
4) S-calculated value was corrected for the presence of a snow bank covering a guiderail

* Signifies a measured increase in sound level rather than attenuation.

Table 1b/ COMPARISON OF MEASURED AND PREDICTED SOUND LEVELS
(Locations Partially Shielded by One Row of Houses)

Measurement Location	After-Construction Sound Levels, L_{eq}		Barrier Insertion Loss, L_{eq}		
	Measured	Calculated BBN	Measured	Calculated BBN	Correction
1	2	3	4	5	6
Locations 1.2 m above ground					
3	57.6	59.5	1.4	3.5	S
22	55.1	58.5	2.5	2.0	S
23	56.8	57.0	1.8	3.0	S
26	59.7	62.0	3.5	3.5	S
33	59.0	58.5	4.2	7.5	-
Average	57.6	59.1	2.7	3.9	-

Notes:

1) Measurement locations are shown in Figure 3 and are documented in Reference 6 and in Appendix A
2) Average measured value if appropriate. Unadjusted for traffic and other variations
3) Adjusted for traffic and other variations using control measurements
4) S-calculated value was corrected for the presence of a snow bank covering a guiderail

* Signifies a measured increase in sound level rather than attenuation.

Table 1c/ COMPARISON OF MEASURED AND PREDICTED SOUND LEVELS
(Locations Shielded by One Row of Houses)

Measurement Location	After-Construction Sound Levels, L_{eq}		Barrier Insertion Loss, L_{eq}		
	Measured	Calculated BBN	Measured	Calculated BBN	Correction
1	2	3	4	5	6
Locations 1.2 m above ground					
1	51.0	54.5	-1.0*	4.5	S
2	57.0	58.0	1.0	3.5	S
15	54.1	56.0	-3.1*	5.0	S
18	50.6	53.0	-2.6*	2.6	S
21	52.1	57.5	-1.1*	1.5	S
24	58.6	58.5	1.4	3.5	S
31	55.1	55.0	4.3	5.5	-
Average	54.1	56.1	-0.6+	3.7	-
Locations at different heights above ground, m					
24:2 m	61.0	59.5	0.6	4.0	S
31:3 m	57.0	56.5	2.6	5.5	-
31:5 m	57.0	58.5	2.6	3.5	-

Notes:

1) Measurement locations are shown in Figure 3 and are documented in Reference 6 and in Appendix A
2) Average measured value if appropriate. Unadjusted for traffic and other variations
3) Adjusted for traffic and other variations using control measurements
4) S-calculated value was corrected for the presence of a snow bank covering a guiderail

* Signifies a measured increase in sound level rather than attenuation.

Table 1d/ COMPARISON OF MEASURED AND PREDICTED SOUND LEVELS
(Locations Shielded by Two or More Rows of Houses)

Measurement Location	After-Construction Sound Levels, L_{eq}		Barrier Insertion Loss, L_{eq}		
	Measured	Calculated BBN	Measured	Calculated BBN	Correction
1	2	3	4	5	6
Locations 1.2 m above ground					
4	53.0	52.5	-3.4*	2.5	S
8	55.0	57.5	0.0	0.5	S
10	59.0	58.0	-7.0*	0.5	S
12	52.9	57.5	1.1	0.0	S
14	50.1	55.5	-1.1*	3.5	S
17	48.4	53.0	2.6	3.0	S
20	50.0	57.5	-6.4*	0.5	S
32	56.5	53.5	0.2	6.0	-
	54.9	57.0	1.0	5.5	-
Average	53.3	55.8	-1.4+	2.4	-
Locations at different heights above ground, m					
24:2 m	61.0	59.5	0.6	4.0	S
31:3 m	57.0	56.5	2.6	5.5	-
31:5 m	57.0	58.5	2.6	3.5	-

Notes:

1) Measurement locations are shown in Figure 3 and are documented in Reference 6 and in Appendix A
2) Average measured value if appropriate. Unadjusted for traffic and other variations
3) Adjusted for traffic and other variations using control measurements
4) S-calculated value was corrected for the presence of a snow bank covering a guiderail

* Signifies a measured increase in sound level rather than attenuation.

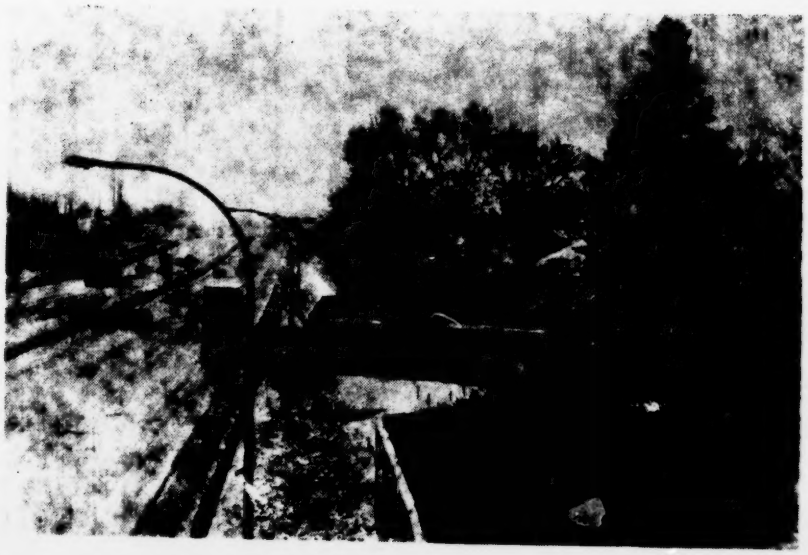

Figure 1/ Barrier View From a Pedestrian Overpass, West (Winter View; a Guiderail Protecting the Protruding Section of the Noise Barrier is Completely Covered by Snow)

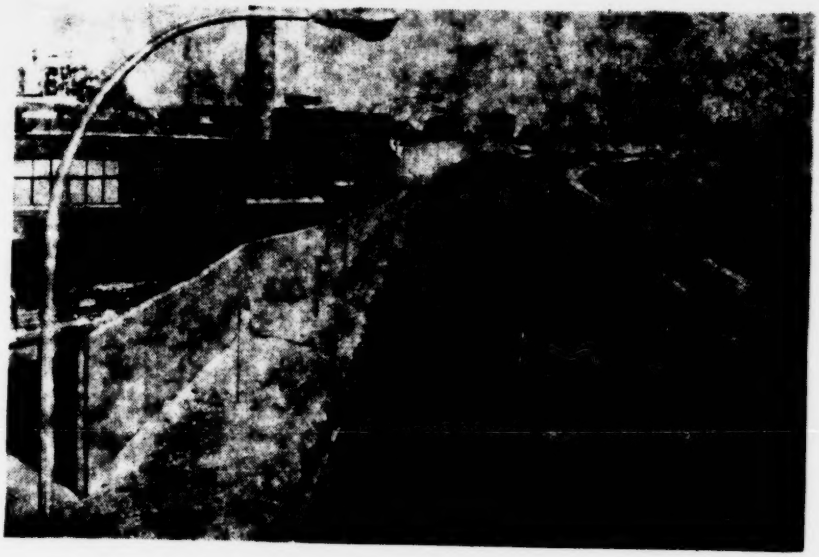

Figure 2/ Barrier View From a Pedestrian Overpass, East (The Gap in the Barrier Wall is for Ramp Access)

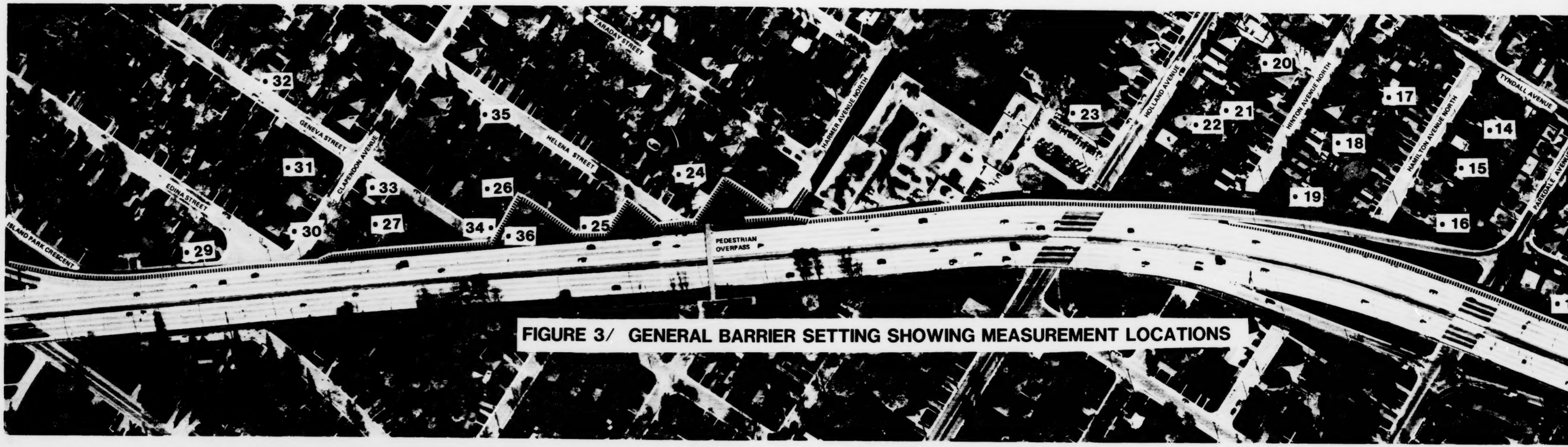

FIGURE 3/ GENERAL BARRIER SETTING SHOWING MEASUREMENT LOCATIONS

CATIONS
HINTON AVENUE NORTH
HAMILTON AVENUE NORTH
TYNDALL AVENUE
PARKDALE AVENUE
FOSTER STREET
SIMS AVENUE
BEVERLY AVENUE
WESTMOUNT AVENUE
ROSEMOUNT AVENUE
HWY. 417 - QUEENSWAY
25 0 50 m
1
2
3
4
5
6
7
8
9
10
11
12
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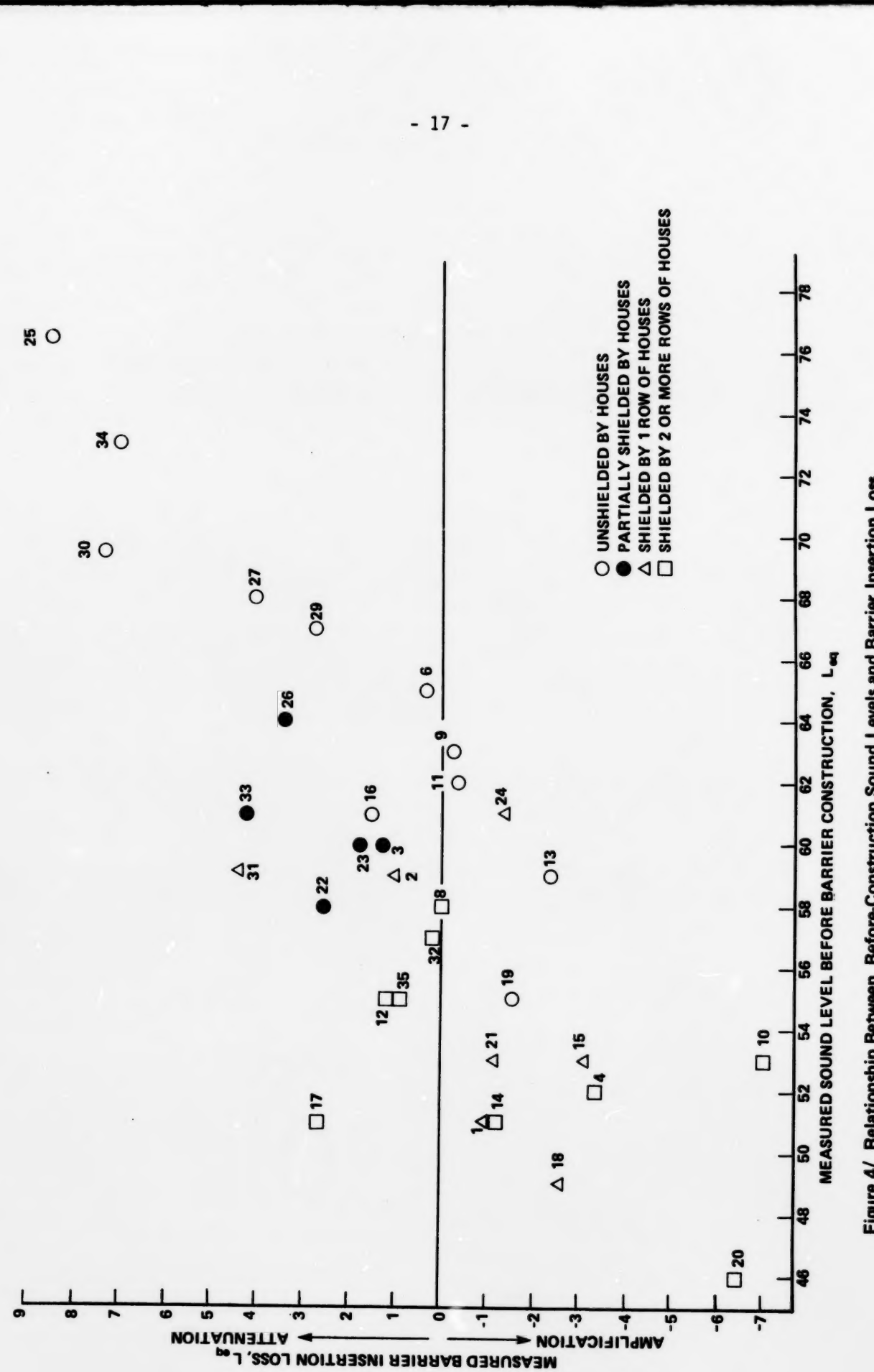
MEASURED BARRIER INSERTION LOSS, L_{es}
ATTENUATION
AMPLIFICATION
MEASURED SOUND LEVEL BEFORE BARRIER CONSTRUCTION, L_{eq}
UNSHIELDED BY HOUSES
PARTIALLY SHIELDED BY HOUSES
SHIELDED BY 1 ROW OF HOUSES
SHIELDED BY 2 OR MORE ROWS OF HOUSES

Figure 4/ Relationship Between Before-Construction Sound Levels and Barrier Insertion Loss

APPENDIX A

Contents

Table A1/ Measured Sound Levels

Figure A1/ Microphone Locations 30, 31, and 33

A2/ Microphone Location 32

A3/ Microphone Locations 34, 35 and Control Measurement

Table A1/ MEASURED SOUND LEVELS

Measurement			L_{eq}			Measured Insertion Loss	
Locat. No.	Date	Time	Control Measurements	Site Measurements	Difference 4-5	L_{eq}	L_{50}
1	2	3	4	5	6	7	8
1B	78-12-18	10:45	80	51	29		
1A	80-07-22	15:16	79	51	28	1.0	2.0
2B	78-12-18	9:45	80	59	21		
2A	80-07-22	14:37	79	57	22	-1.0	1.0
3B	78-12-18	9:45	80	60	20		
3A	80-07-24	11:18	79	57.6	21.4	-1.4	1.0
4B	78-12-19	13:50	82	52	30		
4A	80-07-25	13:50	79.6	53	26.6	3.4	3.0
5B	78-12-19	9:30	81	59	22		
6B	78-12-19	10:15	81	65	16		
6A	80-07-23	9:50	79	64	15	1.0	4.0
6A	80-07-25	9:40	78.9	63	15.9	0.1	2.0
6A	80-07-31	20:25	78.9	61	17.9	-1.9	0.0
7B	78-12-19	13:50	82	50	32		
8B	78-12-19	11:05	82	58	24		
8A	80-07-23	11:00	79	55	24	0.0	2
9B	78-12-19	10:15	81	63	18		
9A	80-07-23	10:30	79	63	16	2.0	3.0
9A	80-07-25	10:12	78.9	61	17.9	0.1	0
9A	80-07-31	20.25	78.6	60.3	18.3	-0.3	0.7
9A	80-11-07	11:55	80	61	19	-1.0	-1.0
10B	78-12-19	9:30	81	53	28		
10A	80-07-25	14:35	80	59	21	7.0	9.0

NOTES:
1) B-Measurement conducted before barrier construction, A-after barrier construction.
2) Control measurement location.
3) Measurement at the location in Column 1.
4) Difference: Average of Column 6 before measurement (B) minus Column 6 after measurement (A). Negative numbers indicate attenuation.
5) Results given for completeness; refer to noise recording sheets for details.

Table A1/ (Continuation)

Locat. No.	Measurement Date	Time	L_{eq} Control Measurements	L_{eq} Site Measurements	L_{eq} Difference 4-5	Measured Insertion Loss L_{eq}	Measured Insertion Loss L_{50}
1	2	3	4	5	6	7	8
11B	78-12-19	11:05	82	62	20		
11A	80-07-23	14:40	80	60	20	0	2.0
11A	80-07-25	10:45	78.9	59	19.9	0.1	1.0
11A	80-07-31	19:50	78.6	59.3	19.3	0.7	1.5
12B	78-12-19	13:10	81	55	26		
12A	80-07-24	10:15	80	52.9	27.1	-1.1	2.0
13B	78-12-09	13:10	81	59	22		
13A	80-07-24	11:50	80	58.6	21.4	0.6	4.0
13A	80-07-25	10:50	78.9	60	18.9	3.1	2.0
13A	80-07-31	19:50	78.6	60	18.6	3.4	3.0
14B	78-12-19	14:45	81	51	30		
14A	80-07-23	9:50	79	50.1	28.9	1.1	5.0
15B	78-12-19	14:45	81	53	28		
15A	80-07-23	10:30	79	54.1	24.9	3.1	5.0
16B	78-12-19	15:30	80	61	19		
16A	80-07-22	14:37	79	56.6	22.4	-3.4	0
16A	80-07-25	10:10	78.9	59	19.9	-0.9	-1.0
16A	80-07-31	21:00	77.6	58	19.6	-0.6	-1.0
17B	78-12-19	15:30	80	51	29		
17A	80-07-23	11:00	80	48.4	31.6	-2.6	2.0
18B	78-12-20	10:05	81	49	32		
18A	80-07-23	14:00	80	50.6	29.4	2.6	8.0
19B	78-12-20	10:05	81	55	26		
19A	80-07-23	13:20	80	55.9	24.1	1.9	5.0
19A	80-07-25	9:40	78.9	57	21.9	4.1	4.0
19A	80-07-31	20:25	78.9	57	21.9	4.1	4.0
20B	78-12-20	11:10	82	46	36		
20A	80-07-23	11:35	79.6	50	29.6	6.4	4.0

NOTES:
1) B-Measurement conducted before barrier construction, A-after barrier construction.
2) Control measurement location.
3) Measurement at the location in Column 1.
4) Difference: Average of Column 6 before measurement (B) minus Column 6 after measurement (A). Negative numbers indicate attenuation.
5) Results given for completeness; refer to noise recording sheets for details.

Table A1/ (Continuation)

Measurement			L_{eq}			Measured Insertion Loss	
Locat. No.	Date	Time	Control Measurements	Site Measurements	Difference 4-5	L_{eq}	L_{50}
1	2	3	4	5	6	7	8
21B	78-12-20	11:10	82	53	29		
21A	80-07-23	12:12	80	52.1	27.9	1.1	4.0
22B	79-01-09	10:45	80	58	22		
22A	80-07-25	11:35	79.6	55.1	24.5	-2.5	-2.2
23B	79-01-09	11:25	81	59	22		
23B	79-11-15	10:15	81	61	20		
23A	80-07-24	12:12	80	54	26	-5.0	-4.5
23A	80-07-28	14:45	79.6	58.4	21.2	-0.2	-2.2
23A	80-07-28	15:20	79.4	58.2	21.2	-0.2	-2.2
24B	79-01-12	11:30	82	61	21		
24B	79-11-14	15:15	79	61	18		
24A	80-07-24	14:30	79	57.8	21.2	-1.7	-0.2
24A	80-07-28	11:55	79.6	59	20.6	-1.1	-1.5
24A	80-07-28	14:05	79.9	59	20.9	-1.4	-0.5
24B-8	79-01-12	12:00	82	61	21	-9.0	-8.7
24A-8	80-07-25	9:40	78.9	57.3	21.6	-0.6	-0.5
25A	80-07-28	11:55	79.6	68.1	11.5	-8.5	-9.2
25A	80-07-28	14:05	79.9	68.1	11.8	-8.8	-9.0
26B	79-01-09	14:10	80	64	16		
26A	80-07-22	15:30	79	59.5	19.5	-3.5	-1.5
26A	80-07-28	14:45	79.6	60	19.6	-3.6	-4.0
27B	79-01-09	14:45	80	68	12		
27A	80-07-22	14:37	79	63.9	15.1	-3.1	-1.2
28B	78-12-18	13:40	81	68	13		
28A	80-07-24	11:18	79	62.8	16.2	-3.2	-3.2
28A	80-07-25	10:50	78.9	62.5	16.4	-3.4	-4.7
29B	79-01-09	15:27	81	67	14		
29A	80-07-22	13:35	79	62.9	16.1	-2.1	1.0
29A	80-07-31	21:00	77.6	62.3	15.3	-1.3	-0.7
29A	80-11-07	12:30	80	61	19	-5.0	-4.0

NOTES:
1) B-Measurement conducted before barrier construction, A-after barrier construction.
2) Control measurement location.
3) Measurement at the location in Column 1.
4) Difference: Average of Column 6 before measurement (B) minus Column 6 after measurement (A). Negative numbers indicate attenuation.
5) Results given for completeness; refer to noise recording sheets for details.

Table A1/ (Continuation)

Measurement			L_{eq}			Measured Insertion Loss	
Locat. No.	Date	Time	Control Measurements	Site Measurements	Difference 4-5	L_{eq}	L_{50}
1	2	3	4	5	6	7	8
30B	79-11-14	10:20	79	70	9		
30B	79-11-15	13:30	80	73	7		
30B	79-12-04	9:02	80	69	11		
30B	79-12-04	10:55	80	66/69.5	14		
30A	80-07-24	16:06	80	60.8	19.2	-8.9	-7.4
30A	80-07-25	14:40	79.6	61.7	17.9	-7.6	-7.7
30A	80-07-24	15:18	80	62.9	17.1	-6.8	-5.7
30A	80-07-25	13:45	79.6	63	16.6	-6.3	-7.7
30B-12	79-12-04	9:02	80	72	8		
30A-12	80-07-24	16:06	80	61.3	18.7	-10.7	-10.0
30A-12	80-07-25	14:40	79.6	64	15.6	-7.6	-10.0
31B	79-11-15	14:50	80	63	17		
30B-20	79-12-04	10:55	80	71	9		
30A-20	80-07-24	16:06	80	67	13	-4.0	-5.0
10A-20	80-07-25	14:40	79.6	66	13.6	-4.6	-7.0
31A	80-07-25	13:50	79.6	54.3	25.3	-5.3	-8.5
31A	80-07-25	15:15	79.6	55.5	24.1	-4.1	-7.2
31B-12	79-12-04	13:30	79	59	20		
31A-12	80-07-25	15:15	79.6	57	22.6	-2.6	-4.0
31B-20	79-12-04	14:00	79	59	20		
31A-20	80-07-25	15:15	79.6	57	22.6	-2.6	-3.0
32B	79-11-14	12:00	79	56	23		
32B	79-11-15	14:10	80	58/57	22		
32A	80-07-28	11:10	79.9	56	23.9	-1.4	-3.0
32A	80-07-28	15:20	79.4	57	22.4	0.1	-2.0

NOTES:
1) B-Measurement conducted before barrier construction, A-after barrier construction.
2) Control measurement location.
3) Measurement at the location in Column 1.
4) Difference: Average of Column 6 before measurement (B) minus Column 6 after measurement (A). Negative numbers indicate attenuation.
5) Results given for completeness; refer to noise recording sheets for details.

Table A1/ (Continuation)

Measurement			L_{eq}			Measured Insertion Loss	
Locat. No.	Date	Time	Control Measurements	Site Measurements	Difference 4-5	L_{eq}	L_{50}
1	2	3	4	5	6	7	8
33B	79-11-14	12:45	79	61	18		
33A	80-07-28	15:20	79.4	60	19.4	-1.4	-4.0
33A	80-11-07	13:00	83	58	25	-7.0	-6.0
34B	79-11-15	9:15	80	73	7		
34A	80-07-28	14:05	79.9	68	11.9	-4.9	-7.0
34A	80-11-07	13:25	81	65	16	-9.0	-9.0
35B	79-11-14	13:40	79	55	24		
35A	80-07-28	11:10	79.9	54.9	25	-1.0	1.2

NOTES:

1) B-Measurement conducted before barrier construction, A-after barrier construction.
2) Control measurement location.
3) Measurement at the location in Column 1.
4) Difference: Average of Column 6 before measurement (B) minus Column 6 after measurement (A). Negative numbers indicate attenuation.
5) Results given for completeness; refer to noise recording sheets for details.

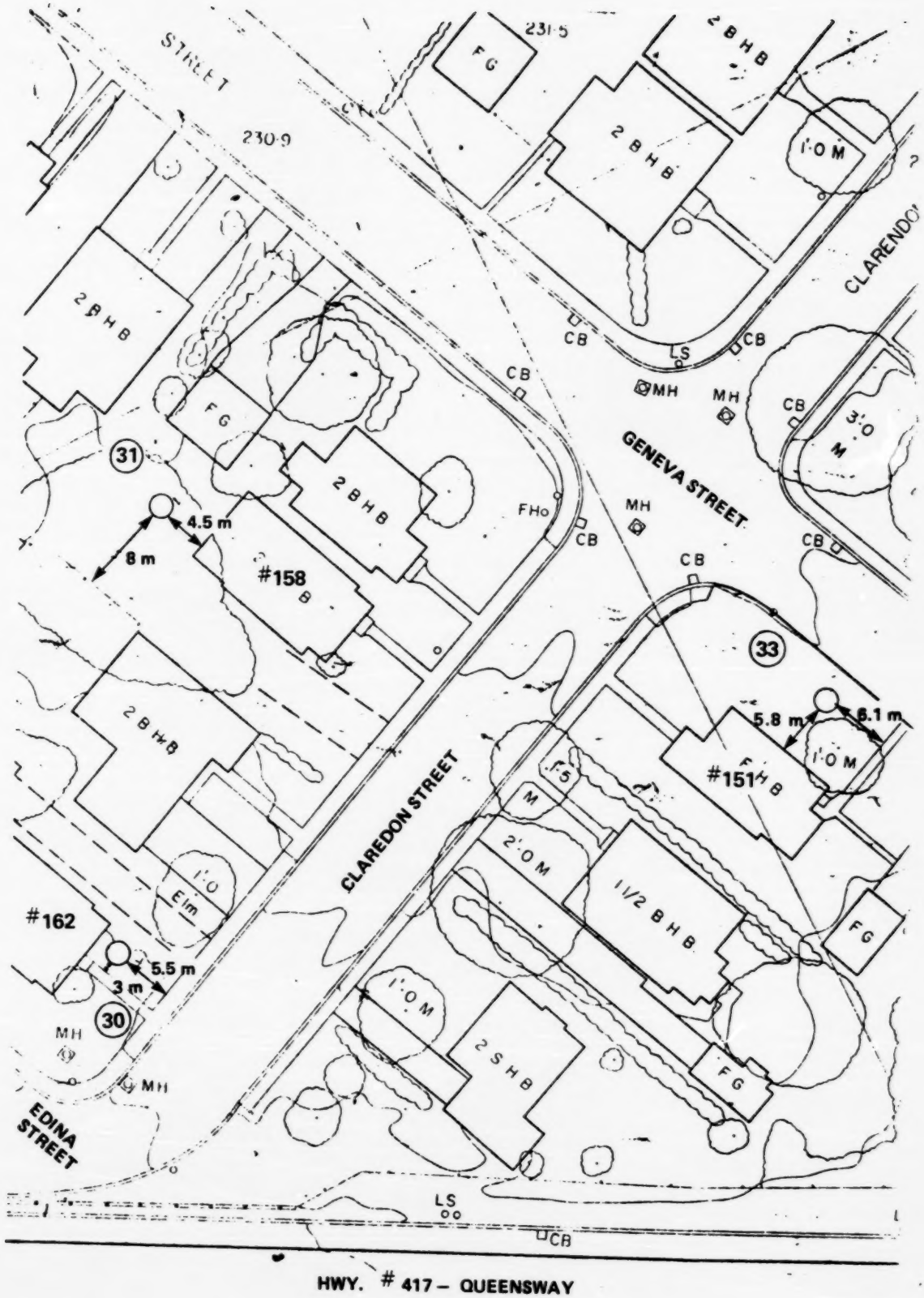

Figure A1/ Microphone Locations 30, 31, and 33

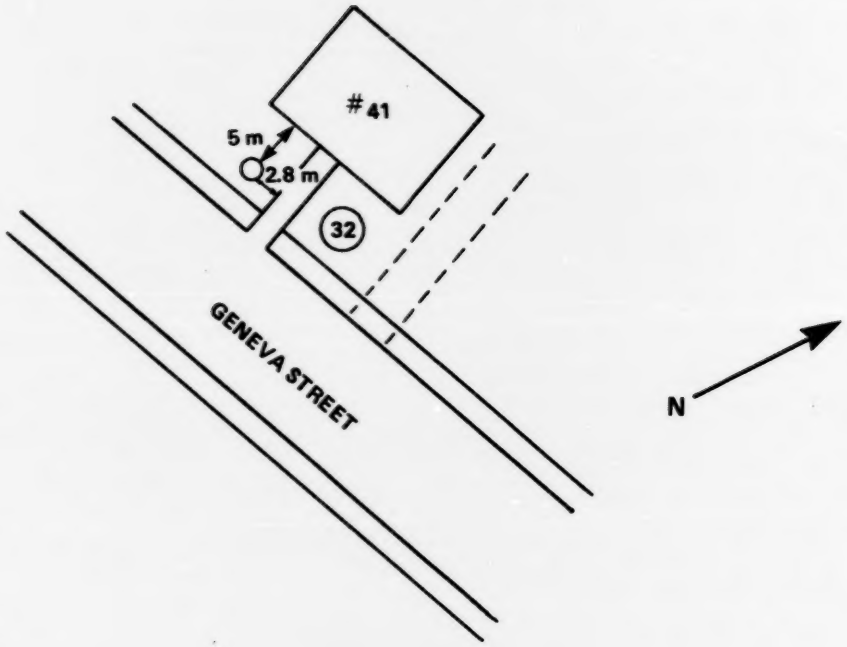

Figure A2/ Microphone Location 32

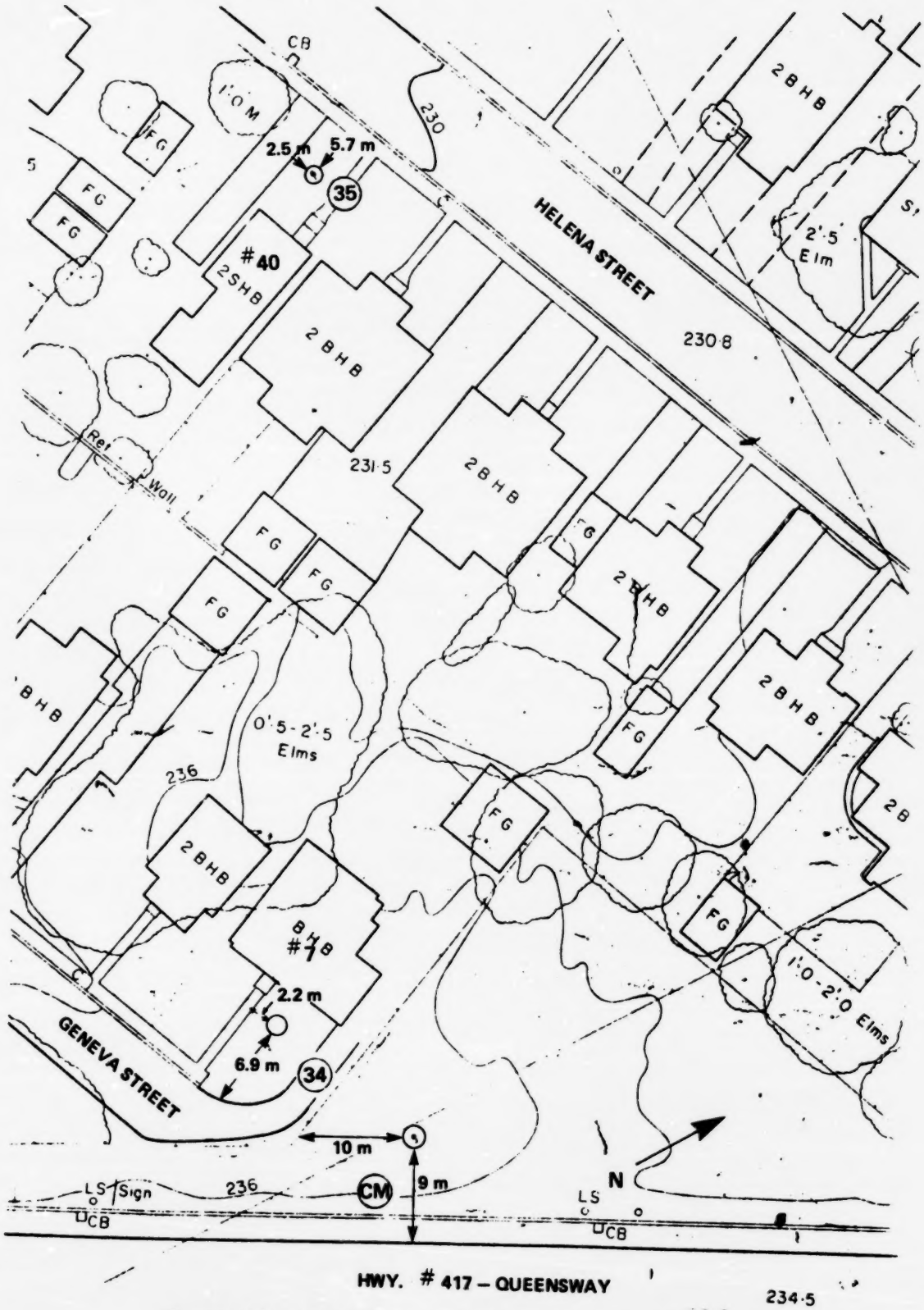

Figure A3/ Microphone Locations 34, 35 and Control Measurement